RIGGING A BIPLANE

by Conrad J. Morgan

To rig a biplane correctly always has presented a difficult problem to builders and restorers.

The object of this article is to acquaint you with some of the many tricks used in rigging. These suggestions are not intended to take the place of instructions issued by the factory but are for those who are building their own ships and also for those who have ships, but no rigging instructions.

The incidence of the wings is determined by the length of the landing gear. If the gear is short, then you must have great incidence angle. The reason is simply this: the incidence is necessary so that when the ship is standing in three-point position, the wing forms an angle to the ground sufficient to give the wing 90 percent of its maximum lift, this giving the minimum landing speed.

You may wonder, then, why we would not make it develop, say 95 or 100 percent of its maximum lift and reduce the landing speed still more? The reason is that the wing would then be too near the stalling angle and any inaccuracy in the rigging or other factors that may enter into the scheme of things, such as bounces and the like, would cause the wing to stall. This would of course result in complete loss of control.

If you do not know the incidence of your ship, don't worry about it, just take the incidence at the root rib of the lower wing and rig that amount into the entire ship. A wing, once it is in the air, automatically adjusts the angle of attack to meet the loads imposed upon it.

Stagger, on the other hand, is simply the disposition of the wings in front of and in rear of, the center of gravity. It gives better visibility to the occupants and increased efficiency to the wing cell. If too much stagger is rigged into the ship, it immediately becomes tail heavy because you have moved the upper wing too far in front of the center of gravity. If too little stagger is used the reverse is true. Dihedral is used as a means of applying a strong corrective force automatically to the ship once it has lost its lateral balance.

It is of utmost importance that the tail assembly be properly rigged. The horizontal stabilizer must be level and the fin vertical. Any inaccuracy here will result in a poor flying ship. The fin should be offset at the forward end to correct for torque. From one to four degrees should be sufficient, the more power the more the offset.

Since the engine turns clockwise, as viewed from the cockpit, offset the fin to the left. It is good practice to rig 30° "up-movement" and 20° "down-movement" in the elevators and 30° to both sides of the rudder.

In rigging the rudder, be sure it is lined up with the fin when taking the angle. The rudder does not line up with the line of flight when you take your feet from the rudder

bar, it lines up with the fin. The reason is this: the fin straightens out the flow of air so that it leaves the fin running parallel to the fin. The rudder then lines up with this flow of air. It is evident then, if the fin is offset, that the rudder will be offset too and if your angles are not taken from this offset position, you will not have enough movement one way and too much the other way.

Now as to the equipment needed. You will need a straight edge long enough to reach from the trailing edge of the wing to a point about a foot in front of the leading edge. This straight edge must be straight. It is a good idea, nevertheless, to show pencil arrows pointing to one of the edges. Keep this edge up at all times and your readings will be more accurate. If you can get an adjustable spirit-level protractor, by all means do so. If you cannot, you will have to make dihedral and incidence boards and use a common level.

To make these instruments, take a common draftsman's protractor and lay off a board the required angle. Make these boards slightly longer than the level you intend using. If you do not know the correct dihedral angle, you can't be far wrong if you use from 2" to 4" depending upon the amount of maneuverability desired, the more dihedral the less will be the maneuverability. If you do not know correct amount of incidence, this can be measured after the ship is leveled in the flying position by placing the straight edge along the first full length rib from the root rib and blocking up under the level until it reads level.

Measure the height of the block and make the incidence board accordingly. You will also need four plumb-bobs and a six-foot rule or yard stick.

Place a couple of horses and jacks under the front landing-gear fittings and take all the weight off the shock absorbers. Place a high horse and jack under the rudder post and bring it up in flying position. Now, place the level across the longerons in one of the cockpits and adjust the jacks under the landing-gear until the ship is leveled laterally.

Next, place the level along one of the longerons and bring the jack up or down until the ship is level fore and aft. Check them both again. Most factory ships have leveling lugs in one of the cockpits for this purpose.

Rig the center-section first. Drop the plumb-bob between the center-section and the outer panel just in front of the front spar. Drop a plumb-bob over the leading edge as close to the ends as possible. With your rule, measure the distance from the lower longeron to the plumb-bob over the end of the center-section. The two sides should be within 1/32" of each other.

To shift the center section from side to side, loosen the cross-wire on the short side and tighten the wire on the long side. These side measurements show that the center-section is equally disposed on the two sides but does not show that it is square with the ship. To check this we measure the stagger.

From the plumb-bob that is dropped over the leading edge of the center section, we measure to the leading edge of the lower wing. Both sides should be as near the same as you can make them. Any slight error here is magnified at the tips.

Care should be taken in making all measurements to see that your rule is held at right angles to the plumbbob and to the point to which you are measuring. The incidence is now checked by placing the straight edge along the end rib of the center section and using the protractor or incidence board and level.

Any changes necessary are now made on the rear struts. Tighten and stream line all wires and check the entire assembly over again. Secure all nuts, bolts, lock nuts and check all struts to see that they are on safely.

Now, take the plumb-bobs from between the center section and upper panels and place them on the upper wings at the outer struts, one on each side. Leave the ones over the leading edge of the center section just as they were.

Be sure that all flying wires and the rear landing wires are loose leaving the front landing wire only to support the wings. Now, placing the straight edge along the line of the front spar, put pencil marks at each end so that you can put it back in exactly the same place each time.

Set the protractor at the desired dihedral angle and don't change it until you have completely finished rigging in the dihedral. The reason is simply this; you cannot set the protractor at exactly the same reading twice in succession. If you keep changing it you never will get both sides to read the same.

After you have set the protractor, place it on the straight edge. Bring the wing up or down as the case may be, until it reads perhaps ten minutes over the desired reading.

When the flying wires are tightened it will bring it down to exactly the right reading. Use the front landing wire only in bringing in the dihedral. The rear landing wire changes the incidence too and would only have to be loosened again.

If you have an adjustable protractor the next step is to box the wings. What is meant by boxing is simply this: putting the same amount of incidence in both the upper and lower wings regardless of what it is. This is done by placing the straight edge on the bottom of the rib on the lower wing just outside of the outer struts and placing the protractor on the straight edge and adjusting it to read zero.

Place the straight edge on the upper wing in the same place and adjusting the struts so that the upper wing has exactly the same incidence as the lower. Care being taken to keep all struts reasonably short. Box both sides and don't worry if they don't read the same. After they are boxed you are ready to bring in the proper amount of incidence by rolling the wings about the lower front spar. Suppose you have too much incidence, you bring it out by tightening up on the front flying wires until the proper amount of incidence is obtained.

If too much tension is required to get the incidence you want it shows the struts are out of tram and must be changed. But before changing the strut length, it is well to check the stagger. Read the stagger at the center section and then out at the struts.

If you have too much stagger you can do one of two things or a combination of the two. You can shorten both the front and rear struts the same amount or you can lengthen the diagonal thus bringing the top wing back so that it can be rolled some more.

If, on the other hand, we get the incidence but are short on stagger we can shorten the diagonal and bring the top wing out or we can run both the front and rear struts out and roll the wing still further. If the chord of the upper and lower wings are the same changing the front and rear strut the same number of turns in the same direction does not change the boxing of the wings.

If you have too much stagger and not enough incidence, tighten the rear flying wires which brings the trailing edges down and the top wing back. On most ships you are allowed up to 1/4" error from tip to tip on the stagger. The whole thing is just a matter of juggling between the incidence and the stagger. Once you see the simple mechanics that rules the movements of the wings, the whole thing is simple.

When you have the stagger and incidence to your liking, bring all the other wires up to the proper tension and streamline them. Check all operations again, all struts to see that you haven't run them out too far for safety, and secure all bolts and lock nuts.

All the ailerons should ride about an 1/8" high when in the air. They are more effective this way and you get better control at the stall and landing. The reason is this, ordinarily the tip will stall before the rest of the wing because of the tip losses. If the aileron rides high it causes the tip to stall later than the rest of the wing giving aileron control up to the very last.

Don't rig any wash into your ship to correct for torque. It isn't necessary as this is cared for automatically the slipstream doesn't flow back in a straight line, it has a corkscrew shape.

This slipstream hits the top side of one wing and the bottom of the other wing, thereby offsetting the effect of the prop. However, the fin should be offset to prevent turning of the ship.

Suppose that the first flight shows the ship to be left wing heavy. Tighten up a half turn on the rear flying wires on the heavy side and loosen the rear landing wire on the same side. A full turn may be necessary. If more than two full turns are necessary, the entire ship should be rechecked.

If a re-rig doesn't do any good, you may get results by the addition of tabs on the upper ailerons. These tabs should be about 10" long and 1-1/2" wide. If your ship is a small one, you may find a smaller tab to be sufficient. Always move the tab in the direction you want the wing to move and remember, you don't have to move the tab but a small amount to get results.

Here is something to remember in landing. If you throttle the motor completely back it slows down the flow of air that passes through it. Quite a few feet of wing area is covered by the slipstream and if the flow of air is slowed down over that amount of wing, the result is an increase in the landing speed. So if you keep the engine turning up a little just enough to not retard the flow of air, you will get the full benefit of the area swept by that air.

All of this is a lot of trouble, but if done correctly, proper rigging will allow the pilot to enjoy the true characteristics of the aircraft design.